Migration of radioactive isotopes in sediments of lakes affected by acid mine drainage - an experimental approach

Fig. 1. A post-mining pit lake at the Łuk Mużakowa (phot.: Ilona Sekudewicz).

Natural radioactive isotopes, such as isotopes of lead or polonium, surrounding us every day. They are present in rocks, sediments, air and water. In natural conditions, where high concentrations of these radionuclides have not been found, they are harmless to living organisms. However, their high concentrations might be hazardous, which can be associated, for example, with uranium deposits. Besides natural radioactive isotopes, also artificial radionuclides might be present in nature, which occurrence in Poland is mainly associated with a radioactive fallout after the nuclear power plant accident in Chernobyl in 1986. As a result of this accident, a significant area of Poland was contaminated with radioactive isotopes, such as caesium ^{137}Cs. Then, due to progressive migration processes, these radionuclides got inside into various elements of the natural environment, including lake ecosystems.

Radionuclides are a valuable source of information on the processes occurring in water reservoirs. They can also be used for dating lake sediments, which allows, for example, to perform palaeoenvironmental reconstructions, including a study on climate changes in the past. In addition, the study of the occurrence and circulation of radioisotopes is extremely important for environmental and radiological protection. Understanding the processes responsible for the distribution of radionuclides in lake sediments can be helpful in preventing the formation of radioactive contaminants, or in predicting potential directions of migration of already deposited isotopes. The significance of this problem is emphasized by numerous scientific studies that were carried out after the nuclear power plant accidents in Chernobyl and Fukushima.

Radioactive isotopes, which are delivered to the lake, are adsorbed on particles of organic matter and minerals that occur in lake sediments (such as clay minerals, oxides, and oxy-hydroxides), and as a result, are immobilized. However, in some cases, they can be remobilized. Scientific research has shown that this may occur in lake ecosystems affected by acid mine drainage (AMD), which can be observed, for example, in the Łuk Mużakowa in western Poland, where acid pit lakes were created as a result of lignite exploitation (Fig. 1). The presented project focuses on the study of the circulation of selected radioactive isotopes in sediments of acid post-mining lakes in which the occurrence of the above conditions has been confirmed.

Therefore, the main aim of the proposed project is to conduct condition-dependent sorption experiments of Pb, Po and Cs isotopes onto a mixture of minerals characteristic of acid pit lakes. Experiments will be carried out under various conditions to investigate how acidification of the environment and the presence of aerobic/anaerobic conditions, dissolved organic matter and microorganisms affect the potential migration of selected radioisotopes. In addition, the presented project aims to investigate the effect of time on changes in the mineralogical composition of the sediment (mixture of minerals) and their importance for the potential release of the studied radionuclides. The obtained results will help to answer the question of which factors have the greatest impact on the sorption processes of lead ^{210}Pb, polonium ^{210}Po and caesium ^{137}Cs isotopes and determine their potential migration in sediments of acid lakes. The last stage of the project will be the calculation of thermodynamic sorption models of selected radioisotopes on sediments (mixture of minerals) under applied conditions. The created models will also enable the analysis of potential directions of radioisotope migration that may occur in the case of changes in the physicochemical parameters of pit lakes related to the progressive neutralization or reclamation treatment of these lakes.